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Abstract

A preliminary study was conducted (n=65) to compare the consistency of measurements of emotional reactions to salt intake using FaceReader (facial expression analyzer) and hedonic self-reports. Study participants tasted six different samples of mashed potatoes with three different concentrations of sodium (Na) (two samples of 0 mg, 178 mg, and 356 mg/15g each). Emotional reactions were measured with FaceReader and self-reported on a 10-point scale, and the mean for each of the different sodium concentrations was calculated. Six different emotional expressions were measured (happy, sad, angry, surprised, scared, and disgusted) for each of the samples. Differences between the means for the two samples with the same sodium concentration were then compared. Our findings have indicated that the differences between the means were lower for FaceReader measurements. These findings occurred more frequently with 16 instances of greater consistency for FaceReader compared with two for hedonic self-reports. Therefore, FaceReader measurements provided more consistent emotional measurements for comparative sodium concentrations than were provided by hedonic self-reports. In particular, the emotions of "happy," "sad," "scared," and "disgusted" were measured more consistently by FaceReader for all concentrations of sodium. FaceReader and hedonic self-reports provide similar results for "angry" and "surprised" .

Furthermore, the cultural background was examined and Primary Study was conducted (n=100) to find if cultural backgrounds have an effect on salt perception between American and immigrant groups, using FaceReader to measure their facial emotional reactions. The American group was comprised of 50 participants and,

comparably, the immigrant group was comprised of 50 participants, in total the Primary Study included 54 males and 46 females. Our findings demonstrate that cultural background has a significant effect on people's taste preference for salt. In particular, Americans have a higher salt preference than immigrants. The fast-food culture, and the increased availability of highly processed and affordable foods manufactured by big food companies in the United States are the main contributors for this difference. Future research in these areas are needed to explore these topics further.

MONTCLAIR STATE UNIVERSITY

EFFECTS OF DIFFERENCES OF MIDDLE EASTERN AND AMERICAN CULTURAL BACKGROUNDS ON SALT PERCEPTION USING FACEREADER: A PIONEERING TOOL TO CAPTURE INSTANT EMOTIONAL REACTIONS

By

Mohamad Bassel Khair

A Master's Thesis Submitted to the Faculty of Health and Nutrition Sciences

Montclair State University

In Partial Fulfillment of the Requirements

For the Degree of

Master in Nutrition and Food Science

May 2016

College of Education and Human Services

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EFFECTS OF DIFFERENCES OF MIDDLE EAST AND AMERICA CULTURAL BACKGROUNDS ON SALT PERCEPTION USING FACE READER; A PIONEERING TOOL TO CAPTURE INSTANT EMOTIONAL REACTIONS.

A THESIS

Submitted in partial fulfillment of the requirements

For the degree of Master of Science

By

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May 2016

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Chapter I

Introduction

Overview

The purpose of this literature review is to review various methods that are available to measure human emotions in response to food. An emotion is a mental and a physiological state that is related with other feelings, thoughts and behaviors. Emotional responses to a specific food are short in duration, intense, and rapid, which is what makes emotions so natural especially during product testing. Accessing research data on salt consumption in the human diet is of utmost importance in order to contribute to the efforts in reducing health risks around the world.

Purpose of study

The objectives of the study include the review of consumer research in product development and how emotional responses are affected cross-culturally. The present research also focuses on exploring the effects of cultural differences on people's perception of salt intake. The purposes of this study includes validating the potential application of FaceReader technology in food and sensory sciences, and to investigate people's salt perception by comparing American versus immigrant populations, using FaceReader technology.

Significance

This pioneering study is one of the first quantitative research investigation demonstrating the validity of FaceReader technology in sensory evaluations applications

in comparison with the traditional hedonic scaling tool. This study explored how cultural differences affected individuals salt perception in the application of FaceReader.

Research Questions

This study hypothesizes that cultural backgrounds play an important role in individual's taste preferences for salt content. The primary hypothesis is that Americans compared to a selected immigrant population prefer food with higher salt concentrations. Furthermore, the traditional hedonic scale method for sensory evaluations may not be as accurate as the FaceReader technology.

Chapter II
Literature Review

In recent years, the study of emotions within the sensory field has become more relevant in product development. Meiselman (2015) has defined emotion as a intense but short-term type of response to a particular stimulus which signals an emotion to a physiological and mental state that is related to other feelings, thoughts, and behaviors. Emotional responses to a specific food are short in duration, intense, and rapid. These factors are the reasons why emotions occur naturally during product testing. Several investigators have used a combination of hedonic self-reports and FaceReader Technology to measure the emotional reactions associated with a product (Nestrud et al., 2015).

Emotion and Food

The reported feelings of the research subjects seem to be stronger and more accurate when measured during the consumption period rather than before consumption. Despite much evidence in the literature that points to the significance of emotion in food consumption, the link between food and emotion remains an under-researched area. Research has demonstrated that emotional responses to foods are related to the health of the participants. For example, a study was conducted in order to compare the negative and positive emotions that arise from past food experiences. This was done in response to actual food samples. The results from this study confirmed that healthy people have a positive disposition toward tasting food; this is called an hedonic imbalance (Desmet & Schifferstein., 2008). The health condition of the subject plays a key role in the outcome

of their relationship between their food intake and their self reported emotion during consumption.

It is important to distinguish between the terms health and wellness in consumer food research. *Health,* refers to the results from biological and/or physical measurements such as: heart rate, blood pressure, body mass index, and cholesterol level. On the other hand, *wellness* refers to the individuals analysis of how they feel (Diener, Sapyta, & Suh, 1998) The distinction between these two terms is extremely important in the field of consumer and sensory evaluations, because wellness is a very arbitrary term, and is defined by the consumer and not the health professional or manufacturer. It is therefore a suitable concept to utilize in matching for the ability of consumer and sensory research science (Meiselman, 2012). Additionally Den Uijlet et al., (2015) found that there are two important factors that can influence the perception of food-evoked emotions measurement results when using the self-reported survey, which are age and olfactory function. In particular, older individuals may lose the sensitivity to detect low concentrations of salty and bitter solutions. This observation was determined when it came to perception of sour and sweet substances (Drewnowski et al., 1996). The research suggested that older individuals who participated in the research needed twice the amount of salt when compared to younger subjects (Drewnowski et al., 2000).

A study by Hartwell, et al (2013), evaluates the relationship between food consumption and emotions (fat, carbohydrate, protein) in a typical large eating environment, specifically, a college cafeteria. They asked 408 participants to complete a questionnaire regarding their own emotions before and after consuming a hot meal in a

cafeteria. The results showed an increase in the satisfaction with food that contained a high amount of fat and protein. However, participants felt unsatisfied with food low in carbohydrates. These results are contradictory with nutrition policy and public health data, thus suggesting a possible link between emotions and the principal macronutrient in the food protein, fat, carbohydrate (Hartwell, et al., 2013).

Cultural Investigations

Additional research showed emotional responses to food vary among participants from different cultural backgrounds, thus acknowledging the need for measurement methods that work between cultures because the translations took away the meaning behind the emotions (Meiselman, 2015). One language may have different words to convey feelings of happiness or contentment, depending on the type and context of the experience. More specifically, studies in emotional expression show differences between subjects from Eastern (European) countries and Western countries as well as differences among two different Western cultures and countries, namely, Ireland and Scandinavi (Tsai & Chentsova-Dutton, 2003).

Furthermore, in the 2013 Pangborn Sensory Science Symposium, Zyl and Meiselman (2013) emphasized the distinction between language and culture. There are several risks in developing an emotional measurement method for use in one country or in one culture shared by many countries and then scaling the same method for application in other countries and cultures. Analysis reveals many differences in interpretation of a single emotion among various societies within and between cultures. Zyl and Meiselman

(2013) study looked at the perception of sodium intake in a diverse immigrant population and has explored sodium in food consumption across cultures.

Sodium content in Food Globally

In many Asian countries, the use of culinary sauces for cooking increases their sodium intake. Nonetheless, it is recommended that the general population should consume 5000-6000 mg of sodium a day. The average consumption of salt in Japan is well above this recommendation. The daily average consumption of sodium in Japan is approximately 10800 mg (National Health and Nutrition Survey 2006). A study was conducted on Japanese adults over the age of 40 to investigate if there was a relationship between the consumption of sodium and blood pressure. They used salt-impregnated taste strips to estimate salt intake and hypertension as determined through the measured blood pressure (Michikawa et al., 2009). The results of this study demonstrate in that the threshold for sodium is associated with hypertension for woman. This study did not find a link between the taste origins for salt among the male subjects. This is due to the fact that it is not common for Japanese men to be responsible for the culinary practices in the household (Michikawa et al., 2009).

Given that a diet with an increased salt intake eventually subdues one's ability to detect the taste of salt (Drewnowski, 1996), an analysis of salt tasting can be useful in evaluating individuals who have high salt intake and risk developing hypertension. Although hypertension is common among individuals with high-sodium diets, key informational data on high blood pressure can encourage people to reduce and maintain levels of salt intake.

Globally, sodium is linked to the intake of other nutrients such as potassium and calcium. Sodium and potassium have similar body functions, such as fluid balance and muscle contraction. However, this is done in an adverse manner where sodium draws fluid out of the cells thereby increasing blood pressure, and potassium draws fluid into the cells, and in turn decreases blood pressure. This is due to the body's natural tendency to maintain homeostasis, as one mineral increases in the body that causes the excretion of other minerals. Both sodium and calcium extraction are controlled by similar systems. This means the body will discharge the excess sodium and also flush calcium out.

In South Africa, 25.2% of the adult population are susceptible for hypertension (Charlton et al., 2004). A study investigated whether usual intakes of sodium differ across South African ethnic groups by estimating the proportion of discretionary and non-discretionary sodium intake and identifying the food sources that are the major contributors to sodium intake (Charlton et al., 2004). Research has suggested that white adult populations that live in Africa have higher sodium intake compared to the black or other ethnicity groups. South African bread is the top food that provides the highest amount of sodium in the diets of South Africans. In addition, cereals are also considered a great contributor to non-discretionary sodium intake in their diets (Charlton et al., 2004). An effective method to reduce sodium intake on a population level is to decrease the sodium content in processed foods. For example, in South Africa bread is an obvious target for sodium reduction at the national level which proves to be a game-changer for South Africans (Charlton et al., 2004).

Sodium is a major food mineral prevalent in many typical American food sources. The Food and Drug Administration (FDA) currently suggests a maximum intake of 2300 mg of sodium per day (6 g of sodium chloride) ("Dietary Guidelines for Americans", 2010). Drake and Lopetcharat (2011) state, "most of the sodium (~75%) in the American diet is obtained from processed foods. Furthermore, the average American adds another 5 to 10% of their total salt intake from a salt shaker" (United States Department of Agriculture, 2005). In the analysis, the intensity of sodium chloride in water was tested from various matrices of dairy products to determine if consumers could tell the difference between sodium content (Drake et al., 2011). The researchers looked specifically at three dairy products: milk-based soups where concentrations are based on 900 mg per ½ cup (120 g) servings, cottage cheese based on 450 mg per ½ cup (113g) servings, and cheese sauce based on 360 mg of sodium per 28 g servings. Of the 75 participants in the study, none of them were on any kind of dietary restriction, including sodium. This is important to note because participants who are already on low-sodium diets are more sensitive to salt than consumers not on low-sodium diets (Bertino et al., 1982; Blais et al., 1986). This research found that consumers were able to detect up to 20% of the difference in the reductions in sodium content (Drake, 2011). Even though consumers are accustomed to foods with a salty taste, and are able to detect salt decrease, food industries are making advancements in their food products to help reduce the negative health implications (hypertension, coronary disease, and stroke) linked to high-salt diets (Law, 1997). A minimal reduction of sodium during a period of time may

be needed to adequately reduce the overall sodium concentration in popular products without losing private consumer loyalty for those products.

Lucas et al., (2011) explored whether sodium chloride (NaCl) concentration in a prototypical food influences the preference for and intake of that food. In the first study using fifty-six participants, researchers used four variations of hash browns. They are identical apart from the concentrations of sodium (40 mg/100g, 120 mg/100g, 170 mg/100g, and 220 mg/100g). Overall, the study proves an individual's salt taste sensitivity, as measured by the recognition threshold, has no association with a favoring for salty foods; however, salt taste sensitivity as measured by a suprathreshold intensity (perceived saltiness) is associated with a liking for salty foods (Keast & Rober, 2007). Lucas et al., (2011) similarly agreed that the affinity for a food changes when single items are evaluated in comparison to a large meal. Thus, saltiness is rated as more intense in multiple items in a meal rather than in a single component. Knowing, observing and measuring consumers' preferences and perceptions of the sensory characteristics of food products is of great importance to food manufacturers and retailers.

Facial Emotion Measuring Techniques

Much of the existing literature on measurement of emotion is based on emotion gauging questionnaires. Some questionnaires listed in the literature are comprised of a list of emotions such as angry, sad, happy, etc. Each emotion in the questionnaire has a subjective scale of 0 - 10, in which 0 reports the user is least angry, sad, and happy, and 10 reports the user is most angry, sad, and happy (Meiselman, 2015). Generally, principal investigators looking to use the hedonic self-reporting technique in their study have

chosen a list of emotions that are most relevant to their objective. Early emotion surveys, generally detected negative emotions especial depression and anger, as they were intended for use within a clinical setting which made sense for those purposes, although product development's aim is to detect a wider aim of emotions (Meiselman, 2015). Furthermore, another measure of emotional responses was the use of functional magnetic resonance imaging (fMRI), which was used to assess the emotional responses during and after showing participants pictures of high and low calorie foods (Tryon et al., 2013).

There are different techniques that study emotional responses to foods. A variation of the hedonic self-reporting technique to measure emotion that also uses positive and negative emotion scales, involves the prioritization of certain emotions that best relate to the research topic. This explains the importance of clearly defining the goal of the research (Meiselman, 2015). The research suggested that a study should be designed to compare one product to another. This would give a quick snapshot of the emotional characteristics of the individuals for the product. This will then allow for the connection between self-emotions and basic psychological processes. The literature advises caution in applying the same emotion lists to stimuli that belong to different categories. The emotion lists used to measure emotional responses to a violent movie are going to greatly differ from the emotion lists used to measure emotional responses to eating one cup of mashed potatoes.

In addition, there are no accepted standard methods for the measurement of emotion (Meiselman, 2004). Another fundamental methodological issue in studying product emotions are when to consider assessing the emotion response; before the

product (evaluated by displaying food pictures or food recall), or during product consumption, or at the moment of the food tasting experience (Jiang et al., 2014). The detected emotion associated with a product can be measured either during product use or immediately after product use as it is a short in duration, intense response to a stimuli, in this case, the product. The most widely used method to measure emotion is during product use.

An early controversial study conducted showed a modern tool called the Passion Product Measuring Instrument (PrEmo - Desmet, 2003), which measured the emotional responses based on fourteen emotions. The tool analyzes all the emotions of the participants based on various variables. These are the dynamics of the face, body, voice, and expressions; all displayed on a computer interface. The participants can then report their responses by comparing their movements to their overall emotions. Moreover, PrEmo was engineered in the context of this existing instrument (Desmet, 2003). This apparatus shows that facial expressions can provide a way to communicate emotions with greater accuracy than verbal expression (Etcoff & Magee, 1992). This seminal technology provided the framework for later research.

Another study named EsSense Profile questionnaire (King & Meiselman, 2010) contained 39 emotions, although a challenge for this questionnaire was the lengthiness of the survey (Nestrud et al., 2015). Results presented from four different studies were conducted in order to develop a shorter version of the original survey after evaluating the semantic structure of the EsSense Profile. In conclusion, both lists gave the same results, although other analyses revealed that there may be a difference in the context of certain

methods which may change across multiple product categories and across many emotions. The researcher can analyze using one or two foods, then 39 questions can give options to "check all that apply" or in a scale type format. However, in many cases across the world sensory examination of multiple products can be done in a short period of time. EsSense 25 survey facilitates this in which the real world events limit the ability to fully analyze the profile of the EsSense action. This research offers the possibility of a more in-depth methodology to reduce the extensive list of conflicts in order to offer insights on whether or not the shorter list limits the ability to create a comprehensive emotional picture analysis.

FaceReader assesses the efficiency in the student's' emotions through a self-assessment test (Terzis, Moridis, & Economides, 2010). The researcher in this study recorded notes in a controlled classroom setting. Statistical analysis proved that there were some differences in FaceReader and self reported analyses. This was in comparison to the results of the emotions of revulsion and anger. Overall, the results show that FaceReader is very accurate in detecting the various emotions of the participants with 87% accuracy. Thus, it can be successfully integrated in a computer-aided learning system in order to increase the accuracy of the recognition. Moreover, this research provided useful results of the emotional state of the students, through learning tests and self-assessment procedures. According to Terzis et al. (2010), FaceReader is a tool that reliably measured and recognized facial expressions by distinguishing six basic emotions, including happy, angry, sad, surprised, scared, and disgusted.

Summary

Emotions are a part of life, and it has been recognized in this literature review that participants' reactions vary due to age, gender, and ethnicity. Furthermore, feelings are very important during learning and self-assessment procedures. In consumer research, there are standard methods for collecting data; however, product oriented emotion measurement is entirely different. For this study on emotions and taste, FaceReader (facial expression analyzer) was chosen for the best outcome due to availability reasons. Other choices for emotions measurement tools include, self-report questionnaires and emotional surveys. Even though there are no standard methods or multiple methods for emotion measurement, the exact process of emotions affecting eating behavior is still an enigma globally. Researchers most importantly should choose the method which best matches their goal.

There are strong links between excessive intake of dietary sodium and the development of unfavorable health consequences for consumers; hypertension is a major concern, which affects many people with a risk factor for the development of stroke and cardiovascular disease. Unfortunately, low-sodium products are bland, tasteless, and boring in flavor. Moreover, when consumers test these products their reactions are more noticeable and objectionable. This is what can make it difficult for researchers to pinpoint human's reaction when tasting various products with low, medium, or high concentrations of sodium.

Several measurement instruments have been used to test emotions to food during consumer trials. FaceReader was found to be a reliable method for this type of research. According to Terzis et al., (2010) FaceReader is able to evaluate the effectiveness of emotions with a greater than 87% success rate in comparison to a self-reported survey. Thus, it can be successfully integrated in a computer-aided learning system in order to affect the overall recognition of the study participants. Moreover, every person has their own unique emotions specific to themselves. Thus, emotional eating is different in comparison between individuals. With many variables to evaluate, it goes to show that the future in the field of consumer and sensory research still requires more investigation to allow for a clearer understanding.

Chapter III

Methods

Two separate methods were used for this study: For the first part of the research (Part I), a calibration study was used to check the validity of FaceReader (Noldus Information Technology bv, Wageningen - The Netherlands). This consisted of a comparison of a hedonic survey with the FaceReader software analysis to see if the latter method is more effective in detecting subjects' emotions. In the second part of the research (Part II), FaceReader was used exclusively to assess reactions to varying sodium amounts among US and immigrant groups. Upon establishing FaceReader's validity in emotions analysis, hedonic self-reporting was dropped for this secondary part of the investigation.

Part I: Methods of the Calibration Study

Participants recruitment

This study utilized a convenient sampling strategy to recruit participants. Sixty-five participants, most of whom were college students, including 24 males and 41 females, were recruited from a diverse population living in proximity to a university. All panelists were asked to read and sign the consent form before participating in the experiment, which was approved by the Montclair State University (MSU) Institutional Review Board (IRB). A screening survey was applied to exclude participants with medical, food allergy, or dietary conditions, and to only accept participants older than 18

years. The screened participants were informed of the purpose, procedures, and hazards of the study.

Lab environment and setting

The experiment was conducted in the Nutrition and Food Science Laboratory at Montclair State University in Montclair, NJ. Participants were seated separately in semi-enclosed booths and were given written and verbal instructions by the facilitator throughout the experiment. Each participant was provided with the necessary utensils as well as water and biscuits to clean their palette. The room temperature was maintained at 72 °F.

Sample preparation

Samples of mashed potato were prepared using dehydrated potato flakes purchased from Augason Farms (1911 south, 3850 West Salt Lake City, Utah 84104 USA). Dehydrated potato flakes and hot water were mixed at the ratio of 1:1 in the food mixer until a uniform texture formed. Six mashed potato samples with three different sodium concentrations were prepared for each participant. Each sample contained a 15 g serving of hot mashed potato. Sodium concentrations of mashed potato samples are shown in Table 1. The sodium concentrations in the original bowls were calculated to ensure that each 15 g sample of mashed potato contained 178 mg (Bowl 1) or 356 mg of sodium (Bowl 2) (Danner et al., 2014). An extreme amount of sodium (356 mg) was used to calibrate the tool. These concentrations of sodium are considered to be in compliance with Generally Recognized As Safe (GRAS) by the United States Food and Drug Administration (FDA). Additionally, a 15 gram sample with no added sodium was

prepared from the remaining bowl (Bowl 3) of mashed potatoes. All samples were then coded with numbers from 1 to 6.

Table 1. Sodium concentrations of samples (mg/g).

Bowl No.	Sample No.	Sodium Concentration mg/g	Net Weight g
Bowl 1	Samples 2, 5	178/100*	15 g
Bowl 2	Samples 4, 6	356/100*	15 g
Bowl 3	Samples 1, 3	0/100*	15 g

*Note: extreme amount of sodium was used to calibrate the tool.

Procedures

At the start of the study participants were asked to have a bite of the biscuit and rinse their mouth with water. Then samples were delivered to each participant in consecutive order (*i.e.* sample 1,2,3…) but not related to the concentration level. For example, the participants received sample 1 first (0 mg sodium), then sample 2 (178 mg sodium - see Table 1). Participants were asked to taste at least half of the sample. After each tasting, participants filled out a hedonic self-report form. This form utilized a 10-point scale (from 0-"not at all", to 10-"extremely" for each emotion) to assess the perceived levels of the following emotional attributes: happy, sad, angry, surprised, scared, and disgusted. Simultaneously, the same attributes with the same scale were measured by FaceReader using a video recording taken with an Axis webcam model M1054 network camera (Axis Communications AB, Emdalavägen 14 SE-223 69 Lund,Sweden) mounted on the wall and connected to a closed-circuit network. Following the completion of sample tastings, each participant was given a debriefing form to address deception issues.

FaceReader setting and emotion measurements

The recorded video was imported into FaceReader following each sample tasting. FaceReader measured the same emotional attributes used on the hedonic self-report including happy, sad, angry, surprised, scared, and disgusted. The resulting data were analyzed using SPSS (IBM SPSS version 22). Emotional attribute means were calculated from the results derived for both hedonic self-reports and FaceReader measurements. Differences between the means of the two samples with the same level of sodium were then calculated ($\bar{x}$ *Different*). These means and standard deviations were then compared to ascertain the difference in consistency between the hedonic self-reports and their corresponding FaceReader measurements.

Part II: Methods for the Primary Study

Recruitment- cultural background

Two cohorts were recruited: American and immigrant. To be considered American, the subject should be living in the USA for more than two years. To be considered an immigrant the subject should only be living in the USA for less than two years. Participants from first world, western countries were excluded from the immigrant group. This group contains subjects originally from countries such as Syria, Lebanon, Egypt, Jordan and Palestine. As with the Calibration Study, this study utilized a convenient sampling strategy to recruit participating panels. Participants were recruited using emails, flyers, and social media. One hundred participants, most of whom were college students, 50 American and 50 immigrant, including 54 males and 46 females, were recruited from a diverse population living in proximity to a university. The same IRB and recruitment requirements for the Calibration Study were applied to-- this

component of the research. Participants were further selected to achieve 50% American and 50% immigrant constituencies.

Table 2. Demographic Characteristics of Participants

Characteristic	Total (n= 100)
Gender no. (%)	
Female	46(46.0)
Male	54(44.0)
Age, y. mean ± SD	23.8±4.46
Education no. (%)	
No schooling completed	0(0.0)
Associate degree	76(76.0)
Bachelor's degree	24(24.0)
Master's degree	0(0.0)
Doctorate degree	0(0.0)
Nationality no. (%)	
USA	50(50.0)
Middle East	50(50.0)
Africa	0(0.0)
Asia	0(0.0)
Europe	0(0.0)
Other	0(0.0)
Ethnicity no. (%)	
White	41(41.0)
Hispanic or Latino	0(0.0)
Black or African American	11 (11.0)
Native American or American Indian	0 (0.0)
Asian or Pacific Islander	0 (0.0)
Arabs	48 (48.0)

Lab environment - Part II

Mostly, the same protocol was used for the laboratory setting as implemented in the Calibration Study, except that experiments were conducted with only one participant

allowed in the room at each sample tasting. This was done in order to avoid communications among participants, which might affect the accuracy of the experiment.

Sample preparation- Part II

Similar to the calibration study, the same dehydrated potato flakes were used in the same ratio but with varying sodium concentrations. Five mashed potatoes samples with different sodium concentrations were prepared for each participant. Each sample contained 15 g servings of mashed potatoes and was served at room temperature (72 °F). The sodium concentrations of the samples were adjusted from the extreme amount used in the calibration study to be more representative of general everyday usage cited in the literature (Danner et al., 2014). The new sodium concentrations of the mashed potatoes samples are shown in Table 2. As before, the concentrations of sodium in each sample (from 0 to 220 mg Na/100g sample) were considered to be in compliance with GRAS by the US FDA. All samples were then coded with numbers from 1 to 5 and served as instructed (see Table 2). Therefore, if a 4 oz standard portion were consumed, a person would ingest either 0 mg of sodium for sample 1, or 302 mg of sodium for sample 2, 1058 mg of sodium for sample 3, 1285 mg of sodium for sample 4, and 1814 mg of sodium for sample 5.

Table 3. Sodium concentrations of samples (mg/g).

Bowl No.	**Sample No.**	**Sodium Concentration mg/g**
Bowl 1	Samples 1	0 Na/100
Bowl 2	Samples 2	40 Na/100
Bowl 3	Samples 3	120 Na/100
Bowl 4	Samples 4	170 Na/100
Bowl 5	Samples 5	220 Na/100

Experimental protocols

Participants were asked to have a bite of the provided biscuit and rinse their mouth with water offered before each sample tasting. A tray was served with five samples of mashed potatoes at room temperature, 72°F. The samples were in stratified order from the lowest sodium concentration to the highest following the sequences protocol established by Lucas et al., (2011). This was done to offset any memory or habituation of sensory glands to higher levels of sodium, which might lower the impact of lower sodium levels later on. Participants were asked to taste and consume at least half of the sample. After each tasting participants were asked to have a bite of the biscuit and rinse their mouth with water (Danner et al., 2014). As in the Calibration Study, the video recording was similarly implemented with the following exception: a green chroma was placed on the wall behind the participants to obtain best resolutions for Facereader analysis.

FaceReader setting and measurements

The hedonic self-reporting was dropped from the investigation due to the validation of FaceReader (See results Part I: Calibration Study) . As before the recorded video was imported into FaceReader following each sample tasting for later analyses.

Statistical Analysis

Data retrieved from FaceReader was analyzed using SPSS (IBM SPSS version 22). The emotional attributes of the two groups (American and immigrant) were calculated and basic statistical information was generated (mean, standard deviation,

sum, and frequency distribution). The mean differences of each sodium concentration sample from the two groups were analysed using Independent-Samples T test, where the alpha value was set at 0.05, to determine if there is significant difference between the two groups.

Chapter VI

Results

Part I: Results of the calibration of FaceReader with the Hedonic scale

There were a total of 65 participants in the experiment, including 41 males (63.1%) and 24 females (36.9%). The average age of the total population was 23.8 years. All participants were university students, of which 38.1% were pursuing bachelor's degrees while 61.5% of them were pursuing associate degrees. Their nationalities included a majority (63.1%) from the Middle East, followed by 27.7% native to America, and the rest from Europe and Asia. Their average years living in the US was 8.9 years. The participants' ethnicity distribution was 44.6% Arab, 40.0% White, 12.3% African Americans and 3.1% Asian or Pacific Islander, See Table 2.

Hedonic and FaceReader Findings

The mean scores and mean score differences ($\bar{x}$ *Difference* for the 6 emotions: happy, sad, angry, surprised, scared, and disgusted*)* were measured using a combination of hedonic self-reported surveys and their corresponding FaceReader measurements. The six attributes were recorded and analyzed using SPSS (IBM SPSS version 22). The mean score differences ($\bar{x}$ *Different)* were calculated to evaluate the accuracy of each method. A lower mean score difference ($\bar{x}$ *Different)* indicated a better accuracy of the method.

For the samples that contained 0 mg of added sodium, the $\bar{x}$ *Different* measured by FaceReader were lower than those measured by self-reported survey in all six emotional attributes tests, suggesting that FaceReader measurements showed a better

consistent performance than the hedonic self-reported survey measurement at 0 mg added sodium. In particular, the "sad" and "scared" emotional attributes (with $\bar{x}$ *Different* of .03 and .02, respectively) measured by FaceReader had the best performance.

For the samples containing 178 mg of added sodium, the $\bar{x}$ *Different* measured by FaceReader were lower than those measured by self-reported survey in emotional attribute "happy", "sad", "angry", "scared", and "disgusted" (except "surprised"). Regarding scores of the "surprised" attribute, the $\bar{x}$ *Different* measured by FaceReader was 0.34, while that measured using self-reported surveys was 0.28. FaceReader displayed better performance than self-reported surveys in most situations (83.3%).

For the samples containing 356 mg of added sodium, the $\bar{x}$ *Different* measured by FaceReader were lower than those measured by self-reported survey in all emotional attributes except "angry". In particular, for the scores of the "angry" attribute, the $\bar{x}$ *Different* measured by FaceReader was 0.40, while that measured by self-reported survey was 0.38. FaceReader's measurement had a more consistent performance in all emotional attributes except "angry" at 356 mg added sodium.

Part II: Results of the effects of cultural backgrounds on salt perception among Americans and immigrant groups

The results are discussed from two different perspectives: a) concentrations of sodium and b) participants' emotions.

a) Concentration of sodium: Table 4 shows the mean scores of each emotional trait as rated by American and immigrant subjects, representing two different cultural perspectives to mashed potato samples with different sodium concentrations. The significant perception differences were observed on samples with extreme sodium concentrations (0 mg sodium sample and 220 mg sodium sample).

For samples with (0 mg) no added sodium, a score of "happy" from immigrants was significantly higher than that of Americans (P value=0.044). While the mean scores of negative emotions ("sad", "scared", and "disgusted") of Americans were significantly higher (P=<0.0001, 0.046, and 0.019, respectively). The American group was more displeased that their immigrant counterpart about their tasting sample of 0 mg added sodium mashed potato. Similar results were recorded in samples with 40 mg added sodium (relatively low sodium level), where the scores of "happy" from immigrants were higher than those of Americans, and scores of "sad" or "angry" were lower than those of Americans.

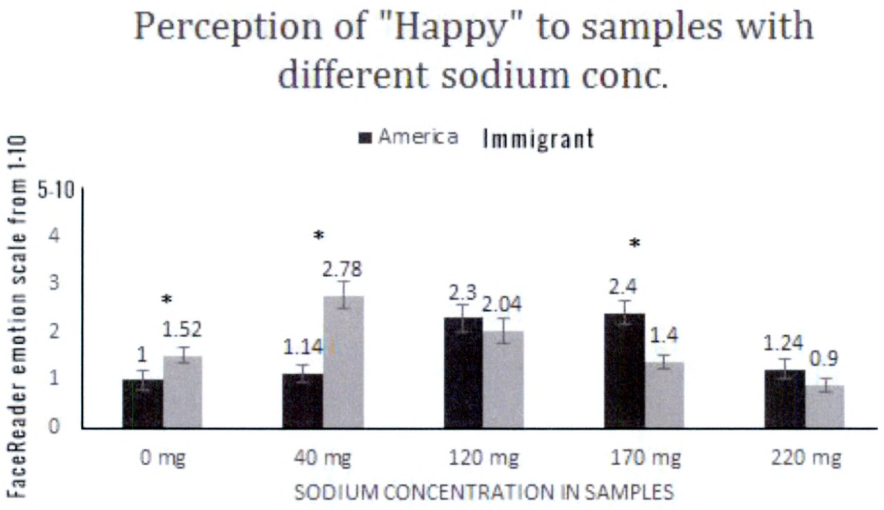
For samples with 220 mg added sodium (highest sodium level in the experiment), immigrants scored higher on negative emotional traits (P values of "sad", "angry", and "scared"=0.007, 0.022, and 0.028, respectively). Equally, similar results occurred with sample with 170 mg added sodium (a relatively high level of sodium), where American scores for "happy" were higher than those of immigrants (P=0.001), and immigrants scored higher than Americans for "angry" and "scared" (P= 0.021). For samples with 120 mg added sodium, neither of the cultural groups showed significant differences in any emotional traits score.

Figures 1 to 6 show participants' perceptions of samples with different sodium levels grouped by emotional traits. Each emotion was rated on a scale of 0 (least) to 10 (most). In order to have a clear comparison, a range of 0 to 5 on vertical axis is shown in the figures.

Table 4. The Mean Scores of Each Emotional Trait Score by Americans and Immigrants.

			Happy			Sad			Angry			Surprised			Scared			Disguested		
Sample ID	Sodium conc. (mg		American	Immigr	*P-Value*	America	Immigrant	*P-Value*	American	Immigrant	*P-Value*	American	Immigrant	*P-Value*	American	Immigrant	*P-Value*	American	Immigrant	*P-Value*
No.1	0 mg	Mean	1.00	1.52	0.044	1.02	0.34	<0.0001	1.24	1.54	0.228	2.70	1.92	0.064	0.38	0.58	0.046	0.98	0.50	0.019
		SD	1.34	1.20		0.96	0.59		1.46	1.34		2.23	1.93		0.49	0.50		1.20	0.76	
		SE	.190	.170		.135	.084		.207	.190		.316	.272		.069	.071		.170	.108	
No.2	40 mg	Mean	1.14	2.78	<0.0001	0.78	0.38	0.019	1.28	0.50	0.002	2.36	2.56	0.165	0.34	0.24	0.275	0.34	0.24	0.53
		SD	1.39	1.98		1.00	0.64		1.54	0.84		1.96	2.02		0.48	0.43		0.48	0.43	
		SE	.196	.280		.141	.090		.218	.119		.275	.286		.068	.061		.100	.078	
No.3	120 mg	Mean	2.30	2.04	0.493	0.68	0.80	0.463	0.96	0.98	0.932	2.16	2.26	0.81	0.38	0.42	0.687	0.90	1.22	0.104
		SD	1.93	1.85		0.87	0.76		1.50	0.71		2.12	2.02		0.49	0.50		0.91	1.04	
		SE	.273	.262		.123	.107		.212	.101		.300	.285		.069	.071		.129	.146	
No.4	170 mg	Mean	2.40	1.40	0.001	0.92	0.94	0.929	1.32	0.80	0.021	3.00	3.10	0.831	0.38	0.56	0.073	1.16	1.38	0.473
		SD	1.74	1.01		1.08	1.17		1.36	0.78		2.52	2.13		0.49	0.50		1.35	1.69	
		SE	.246	.143		.153	.165		.193	.111		.357	.301		.069	.071		.190	.239	
No.5	220 mg	Mean	1.24	0.90	0.21	0.70	1.28	0.007	0.96	1.50	0.022	3.46	2.48	0.036	0.38	0.80	0.028	0.92	1.34	0.085
		SD	1.56	1.09		0.74	1.28		1.11	1.22		2.52	2.08		0.49	0.49		1.10	1.30	
		SE	.221	.155		.104	.181		.156	.172		.356	.294		.069	.070		.156	.184	

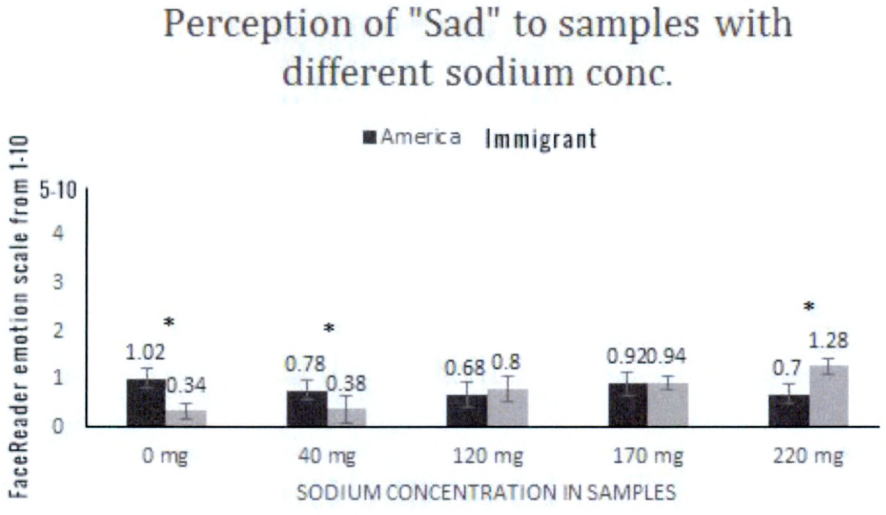
Figure 1. Perception of "happy" to samples with different sodium concentration



* Significant at $p<0.05$

b) Participants' emotions: Looking specifically at the emotions, (Figure 1), the immigrant group showed preference for samples with lower sodium content. In samples with 0 mg and 40 mg added sodium, immigrants reported feeling significantly more "happy" than Americans did (P=0.044 and P=<0.0001, respectively). In contrast samples with 170 mg added sodium (considered a high sodium content sample), Americans felt significantly more "happy" than the immigrants (P=0.001). As for samples with 120 mg and 220 mg added sodium, there were no major differences in the "happy" score between these two groups. These results suggest that immigrants preferred the low salt samples while Americans favored those samples with relatively high salt content.

Figure 2. Perception of "sad" to samples with different sodium conc.

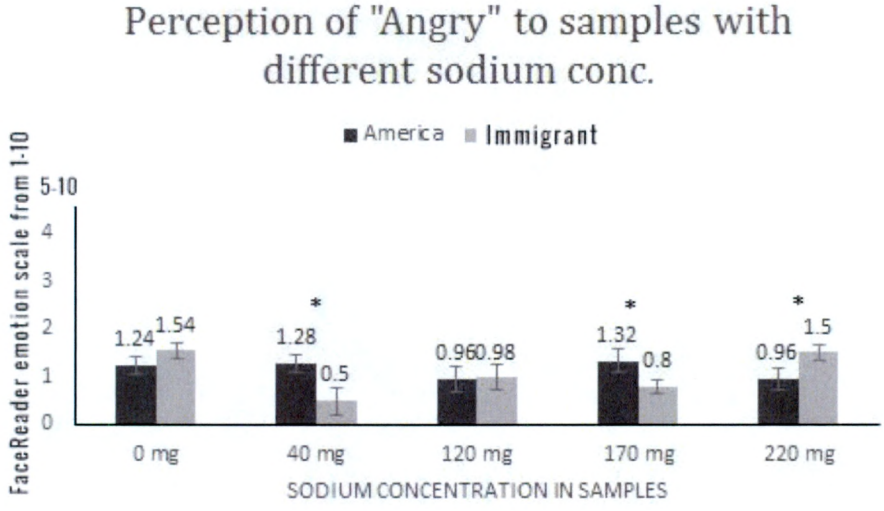


* Significant at p<0.05

Figure 2 shows that Americans disapproved of samples with low sodium content (0 mg and 40 mg), while immigrants reported feeling more "sad" than Americans for samples with the highest sodium concentration. The American group felt significantly

more "sad" than immigrants toward samples with 0 mg and 40 mg added sodium (P<= 0.0001 and P=0.019, respectively). The scores rated by immigrants toward samples with 0 mg and 40 mg added sodium were very low (0.34 and 0.38, respectively), suggesting that the immigrants did not dislike the samples with low salt. In contrast, the immigrants felt significantly more "sad" than the Americans did toward the sample with the highest added salt content (220 mg - P=0.007). It is important to note that there are no significant differences between Americans and immigrants in samples with 120 mg and 170 mg added salt. Americans and immigrants are almost equally disappointed or "sad" with the mashed potato samples that had 120 and 170 mg of added sodium.

Figure 3. Perception of "angry" to samples with different sodium conc.

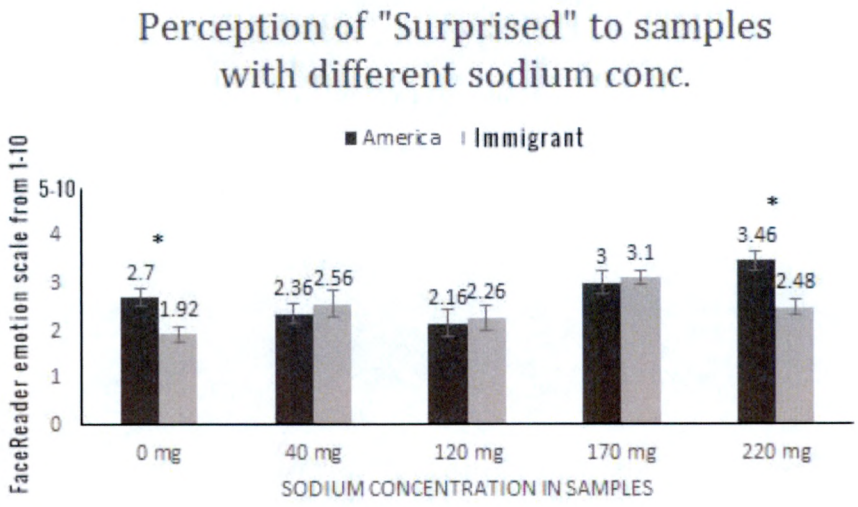


* Significant at p<0.05

Regarding the emotional trait of "angry", the results were mixed. Americans felt significantly more "angry" than immigrants toward samples with 40 mg (considered as low sodium content) and 170 mg (considered as high sodium content) added sodium

(P=0.002 and P=0.021, respectively). Immigrants felt significantly more "angry" than Americans did about samples with 220 mg added salt (P=0.022). No significant difference was found in the sample with 120 mg added sodium in either group.

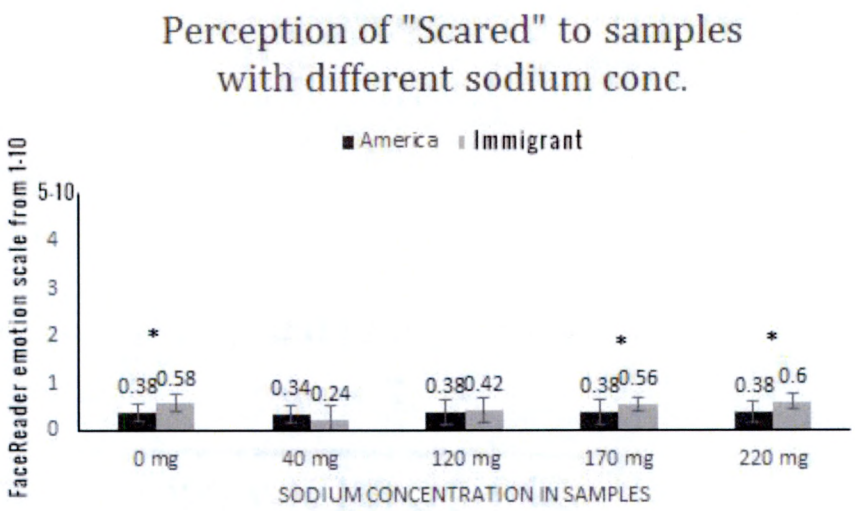
Figure 4. Perception of "surprised" to samples with different sodium conc.



* Significant at $p<0.05$

In looking at the scores for emotional traits of "surprised", Americans reported significantly more "surprise" than immigrants about samples with 0 mg and 220 mg added sodium (P=0.064 and P=0.036, respectively). There are no marked differences between the subject groups in samples with 40 mg, 120 mg and 170 mg added salt.

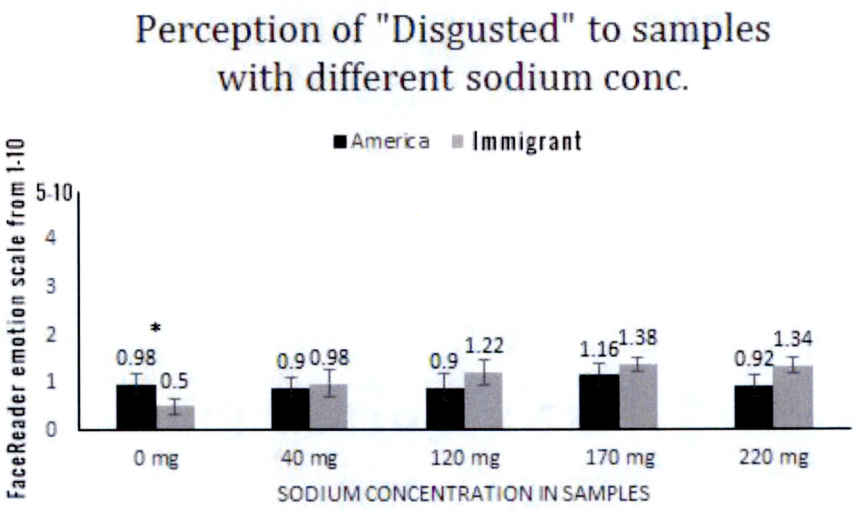
Figure 5. Perception of "scared" to samples with different sodium conc.



* Significant at $p<0.05$

Standard deviations in survey scores specifically concerned with the emotional trait of "scared", within each group were relatively high compared with other emotional traits, highlighting individual preferences within the groups. Immigrants felt significantly more "scared" than Americans did toward samples with 0 mg and 220 mg added salt, the lowest and highest added sodium samples in this experiment (P=0.064 and P=0.028, respectively).

Figure 6. Perception of "disgusted" to samples with different sodium conc.



* Significant at $p<0.05$

Analysis of scores for the emotional trait "disgusted" showed Americans felt significantly more "disgusted" than the immigrants did in samples with 0 mg added sodium (P=0.019). No other significant differences are observed for the rest of the sodium concentration groups.

Chapter V

Discussion

Part I: Discussion of the Calibration Study

Overall, the mean score differences calculated for most of the emotional attributes across different sodium concentrations were lower in FaceReader than the self-reported hedonic survey with 16 instances of greater consistency for FaceReader compared with two for hedonic self-reports (for "surprised" with 178 mg and "angry" for 356 mg). This indicates a greater consistency and sensitivity in FaceReader measurements compared with self-reported hedonic survey results. More specifically, the best performances (in their consistency and accuracy) recorded by FaceReader measurements were those that detected emotional attributes "sad," "scared," and "disgusted" under varying sodium concentrations.

Part I: Discussion of the effects of cultural backgrounds on salt perception among Americans and immigrant group

In the current study, we explore how people respond to a particular stimuli, in this case salt, using FaceReader as an application of in cognitive research. FaceReader software was used to detect six emotional expressions: happy, sad, angry, surprised, scared, disgusted, and a neutral state.

Due to its low cost and functional properties in foods, salt is one of the most widely used additives in the food industry. In developed countries the average total daily intake of sodium per adult is 4—5 grams of sodium, which is about 25 times greater than the minimum daily requirement. This trend has led to greater awareness of the negative

effects associated with excessive intake of sodium, which has been associated with hypertension and consequently an increased risk of chronic cardiovascular diseases (Albarracin, W. et al, 2011). This study explores the effect of different sodium concentrations on people's emotions, and examines the influence of cultural backgrounds on the perception of salt. The results of the six emotions are discussed below.

Of all the emotions measured during this study, perhaps the measurement of "happy" is most telling of approval and satisfaction for the tested product. A look at Figure 1 of the "happy" results shows immigrants were happier than Americans with low sodium concentration samples (Figure 1.). One possible explanation could be that a local American diet is rich in highly processed foods generally found at the market or third-party prepared meals from restaurants that are relatively high in sodium content. For immigrants, whose daily diets seldom include an American staple such as mashed potato, it is hard to form a cognitive bias towards a preferred taste for mashed potato. It is not surprising that Americans felt significantly more happy than immigrants about samples with relatively high sodium concentration (170 mg) (2.4 vs. 1.4 respectively, see Figure 1.). Among the samples used for testing, those with relatively high sodium concentration were closer to the sodium content found in a typical American side of hot mashed potato.

It is fair to assume that the emotion "sad" is the opposite of "happy". This is echoed in the findings in Figure 1 where Americans felt significantly more sad about samples with low sodium concentration (0 mg and 40 mg, see Figure 2). Immigrants were disheartened with the highest sodium concentration sample (220 mg, see Figure 2). The study's group of immigrants are largely native to the Middle East, and therefore

culturally accustomed to a Mediterranean diet where most of the ingredients are fresh. In fact the Mediterranean diet uses far less processed ingredients resulting in an overall sodium content that is lower than its equivalent American diet. Immigrants who sampled high sodium potatoes reported feeling sad, and that is possibly because it deviates from their native food's regularly low sodium content. Given that the typical American diet is relatively salty, it is not surprising that Americans reported feeling sad about potato samples low in sodium.

Similarly in results relating to the feeling of "angry", it is reasonable that Americans felt significantly more angry than immigrants in samples with the lowest sodium concentration (40 mg, see Figure 3). In the reverse, immigrants felt more angry than Americans about samples with the highest sodium concentrations (220 mg). It is odd to note that Americans felt significantly more angry than immigrants in samples with 170 mg sodium content, (1.32 vs. 0.8 respectively, see Figure 3). People seem simultaneously "happy" and "angry" about the same sample as was the case with Americans' judgement of the mashed potatoes with 170 mg added salt. A potential explanation could be the mechanism the FaceReader system analysis uses for each emotion. The facial response captured by FaceReader automatically generates rating scores for all six pre-set emotions. In other words, rather than absolute values, the scores rated by FaceReader for each emotion are relative values, which are only true in certain situations. In comparing the emotion values between groups, results that are solely based on one emotion score may be bias and incompatible with each other. The results are discussed with an inclusive consideration for all six emotions in this study.

Analysis for the results "surprised" demonstrated that Americans felt significantly more surprised about both samples with the lowest and highest added sodium (0 mg and 220 mg). Although Americans are generally used to a high sodium diet, the sample with the highest salt content (220 mg added salt) invoked surprise in Americans rather than other more negatively nuanced emotions including sadness, anger, and disgust.

Scores for "scared" and "surprised" were similar in that they mirrored the same emotion expressed by immigrants and American subject groups, respectively. While immigrants felt significantly scared about the sample with lowest sodium concentration (0 mg) and the sample with highest sodium concentration (220 mg), Americans felt equally surprised by both the lowest and highest salt content samples. As discussed before, the immigrants felt "scared" about the sample with highest sodium concentration because they also felt angry and "sad" about the too much high saltiness. They felt more "scared" about the samples with 0 mg added sodium maybe because mashed potatoes are new to them, and the new dish with almost zero saltiness scared them.

The emotion "disgusted" expresses a more extreme disapproval of the tested product. Since Americans are regularly exposed to highly processed foods with added salt in their diet, it is reasonable that Americans were most disgusted with the 0 mg added salt sample.

Overall, the results indicated that immigrants have a higher acceptance than Americans for foods with less sodium. By contrast, Americans have a higher tolerance and acceptance for salty foods. Furthermore, as mean scores for "happy" go up, the inverse occurs for "sad", "angry", "scared", and "disgusted".

Chapter IV

Conclusion

Part I: Conclusion of the Calibration Study

This Calibration Study has demonstrated the potential usefulness of employing FaceReader to understand emotional reactions to salt intake. By using FaceReader, it is possible to record, measure and analyze emotional responses that are otherwise difficult for individuals to self-report. Nevertheless, emotions still play a significant role in influencing dietary intake. The average intake of sodium by Americans currently exceeds recommended levels. By understanding emotional reactions that are expressed and measured by FaceReader, it may be possible to recommend lower levels of sodium intake in specific foods while not compromising the pleasure that tasters experience.

The conclusions of this study are limited and preliminary because of the small sample size. However, the research is on-going and more participants will be recruited. Future analysis will focus on analyzing gender-related differences, and investigating the differences between reactions of American-born study participants and immigrants.

Part II: Conclusion of the effects of cultural backgrounds on salt perception among Americans and immigrant group

Cultural background has a significant effect on people's taste preference for salt. In particular, Americans tend to favor more salt than immigrants in their food. The American fast-food culture and the rise in access to mass produced foods that are affordable and poor in nutrient value is a major contributor to the perception differences

to salt among Americans and immigrants. FaceReader is a new tool in cognitive research that has the potential to play an important role in reducing dietary intake of sodium in future generations.

Chapter VII

Limitations/Delimitations

Part I: Limitations of the Calibration Study

This study presents a few limitations that are discussed below. Primarily, the experiment had a sample size with 65 total participants, largely (63.1%) native to the Middle East. Undoubtedly, a larger and more diverse target population is necessary to confirm the validity of the conclusion. Different sodium concentrations were used as markers to trigger participants' emotional reactions in the current study. In order to have a comprehensive picture of the FaceReader, other sensations, like perception of sweetness, sourness, and bitterness require further study using FaceReader. Also, the extreme amount of sodium that was used to calibrate the tool was not realistic in everyday life.

The classifications of emotional expressions for the purposes of this study were limited to the six emotional expressions classified by FaceReader (happy, sad, angry, surprised, scared, and disgusted). Minor and subtle emotional expressions such as neutral or mild were not captured by FaceReader, which diminishes the validity of the tool. Other emotion measurement methods used 39 emotions during product research (Nestrud et al., 2015). In our study, we used only the six emotions (happy, angry, sad, surprised, scared, disgusted) that FaceReader provided. Also, the implementation of FaceReader measuring requires relatively strict conditions (indoor condition, participant spotting, lighting, and other hardware and software requirements) that may limit its applicability under more

flexible conditions. The researcher could have used rice which is more popular across cities groups but potatoes are more consistent and easier to prepare at the food lab.

Part II: Limitations of the effects of cultural backgrounds on salt perception among Americans and immigrant group

The limitations of the present study include the time of data collection, the language of the study materials and the number of emotions. Emotional responses can be collected during the test, not before, during, and immediately after the product is tested, as suggested by Jiang et al. (2014). Another limitation faced during the study was that the survey materials were only offered in English excluding the transliterated and translated meanings from immigrant languages like Arabic, for example. While there are other emotion measurement methods that used 39 emotions during product research (Nestrud et al., 2015), this study uses the six emotions (happy, angry, sad, surprised, scared, disgusted) provided by FaceReader.

The current FaceReader version has a number of limitations. The current version is not programed to work with young children under three years old. Glasses may hinder classification and especially thick and dark frames can significantly reduce performance. It may be useful to have a number of rimless reading glasses available in a few strengths during a test. Movement, pose, and rotation of the test person compromise analyses. The participants should sit or stand also he should look frontally into the camera and the angle should be less than 40°. It is very difficult to analyze a person's facial expressions during eating, because the person may cover part of his face using his hand when he or she puts food in his or her mouth. FaceReader can only analyze one face at a time.

Multiply facial images in the same frame cannot be analysed; imaging must be separately recorded.

The classifications of emotional expressions for the purposes of this study were limited to the six emotional expressions classified by FaceReader (happy, sad, angry, surprised, scared, and disgusted). Minor and subtle emotional expressions such as neutral or mild were not captured by FaceReader, which diminishes the validity of the tool. Other emotion measurement methods use 39 emotions during product research (Nestrud et al., 2015). In our study, we used only six emotions (happy, angry, sad, surprised, scared, disgusted) that FaceReader provided.

Chapter VIII

Future Research

Future research for the Calibration Study (Part I)

Further research is needed to confirm the initial results found in this preliminary study using FaceReader. Once the validity of the FaceReader is confirmed, it can be used as an effective tool to measure what no other tool is currently capable of measuring: instant emotional expressions. There are plans underway to explore salt thresholds for Americans and the Arabs using FaceReader as a measuring tool. The salt threshold for an American is expected to be different compared to that of Arabs.

Future research for the Primary Study (Part II)

Future research is needed to testify whether FaceReader can be used to reduce the dietary intake of sodium by accurately calculating the minimum salt necessary in food to meet people's satisfaction. If the effectiveness of FaceReader is confirmed in salt cognition research, there can be wider applications for this tool in other taste cognitions and food and sensory sciences.

Chapter IX

Implications

Implications from the Calibration Study (Part I)

This preliminary study examined the value of a new tool in capturing instant emotional changes. Compared with the self-reported hedonic survey, the FaceReader results exhibit superior consistency and accuracy. Currently, there is no other tool that can measure instant emotional expressions accurately while simultaneously generating quantitative data. The application of FaceReader is able to fill in gaps in capturing the real instant of emotional expression. Once the validity of FaceReader is confirmed, it can be applied to many different areas and generate huge effects. In medicine, facial signals can be measured to identify specific mental processes (den Uyl. & Kuilenburg. 2005). In education, students' facial expressions can give educators direct feedback on their instruction styles. The application of FaceReader in sensory evaluation can immensely benefit the food industry by providing more accurate feedback a faster and more effective evaluation process.

Implications from the Primary Study (Part II)

This study confirms that cultural backgrounds play an important role in people's taste preferences. In comparison to immigrants, Americans' high dietary intake of sodium reflects the fast-food culture, and the food industry's influence on people's taste preferences. The FaceReader application used in this cognitive research has proven useful for further nutrition and food research.

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